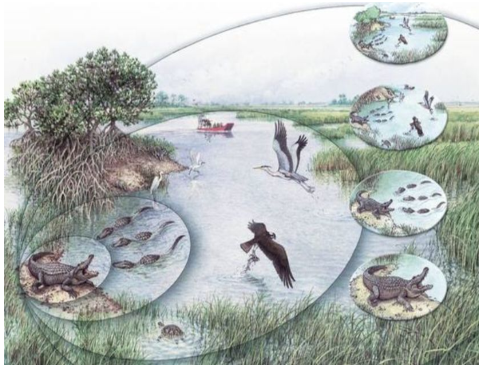
Advancing Large-Scale Marsh Adaptation Projects through Multi-Disciplinary Communication and Landscape Change Visualization Products

by Paul Cirillo, Mia McNinch, Ilana Greenspan, William Zong

Who we are!

Ecosystem Science & Management



Geospatial Data Science

M SEAS

Project Context

- Advised by Julie Reichert-Nguyen (NOAA) and Emily Thorpe (JBO Conservation)
    - Client: Envision the Choptank
- Advancing the Chesapeake Bay Program’s larger wetland restoration project

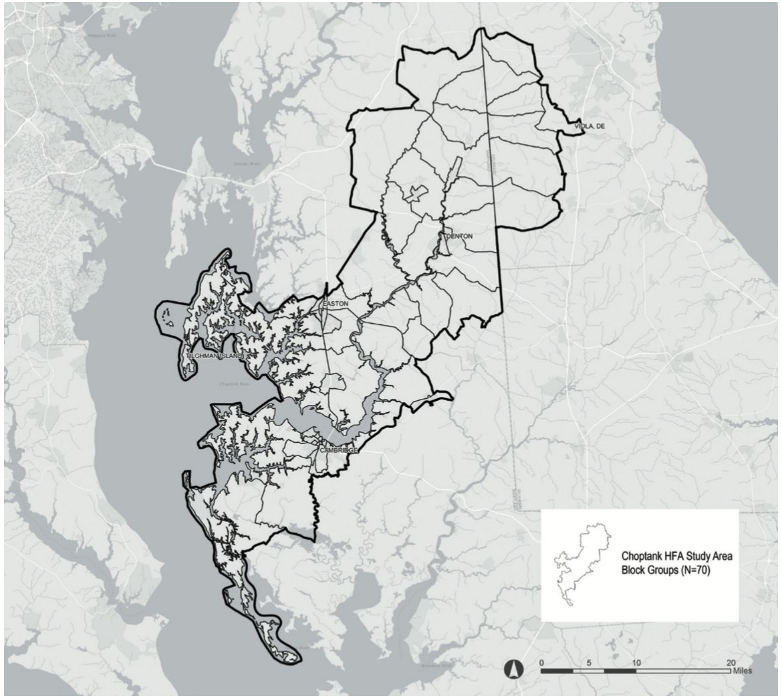
The Choptank River: An Overview

The Choptank River system is well studied related to nitrogen and phosphorus pollution and oyster restoration. Less studied are tidal freshwater marshes where there is a need for management recommendations to address environmental change.

Relevant Concerns:

- Limited observed data
  - Sea Level Rise (SLR) and saltwater intrusion (SWI) monitoring
  - Sediment Accretion
- Invasive species management
- Unique sociological concerns

Marsh Types: saltwater/brackish, non-forested tidal freshwater, and forested tidal freshwater wetlands



Marshes of Interest

Project Objectives and Deliverables

Objectives:

For Tidal Wetlands in Choptank River

1. Characterize the historical changes.
2. Characterize current ecological and social conditions.
3. Identify resilience strategies of highest benefit that consider the ecological and social contextualization of the wetland and projected changing climate conditions in the region.
4. Evaluate models of future marsh migration scenarios that account for sea level rise, marsh health, and potential coastal flooding that will aid practitioners in identifying areas for the most effective implementation.

Deliverables:

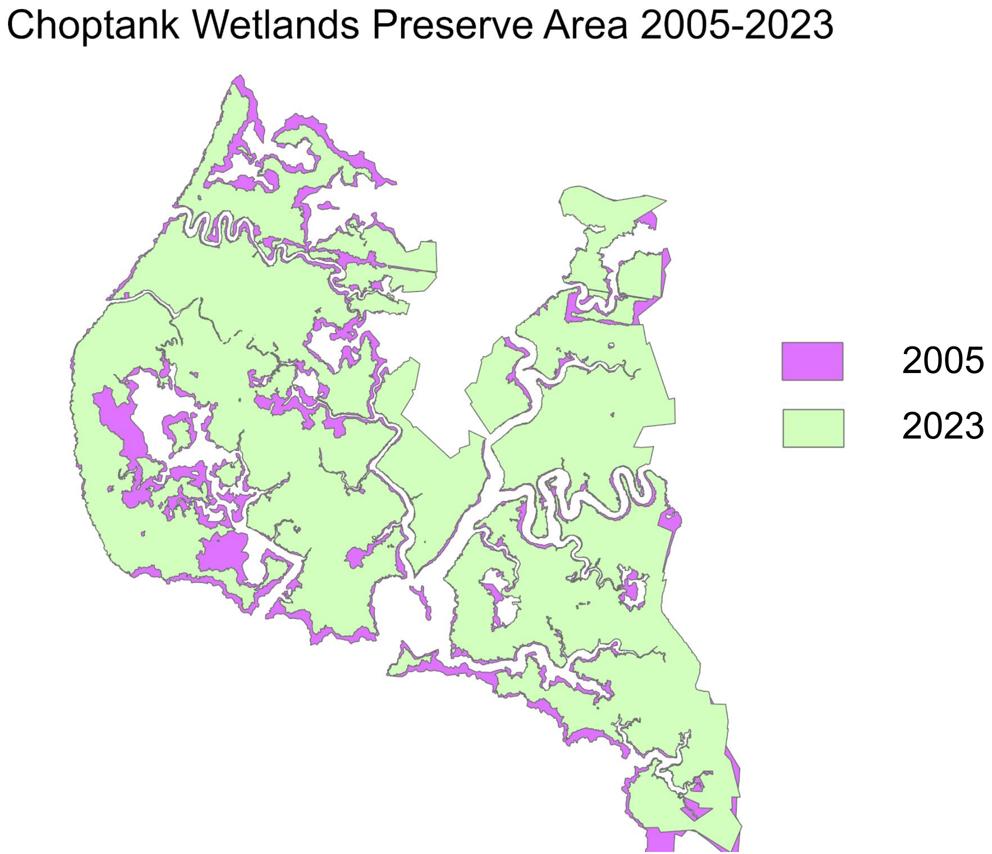
1. Coastal Wetland Resilience Plan for the Choptank River Ecosystem
   a. Literature review
      i. Native and Invasive species presence
      ii. Temporal changes to the system
         1. SLR and SWI
      iii. Sociological Conditions
   b. Professional Interviews
2. Public Mapper of Choptank River Marshes
   a. Historical changes
   b. Future projections

Project Timeline

- Winter 2025
    - Began meeting with clients and refining project scope
- Spring/Summer 2025
    - Finalized project plan
    - Began collecting data for literature review
    - Began professional interviews
- Fall 2025
    - Meet with working groups and teams to refine project deliverables
- Winter/Spring 2026
    - Present finished project (April 2026)

Historical Changes to Marshland

- Using high resolution aerial imagery to digitize layers at different times
- **Goal**: calculate rate of loss for 5 marshes of interest



Unvegetated:Vegetated Ratio

- Unvegetated Vegetated Ratio (UVVR) annual data from 1985-2022
- Classification scheme:
  - **0 - 0.1**: Healthy/Stable - Conservation (green in maps)
  - **0.1-0.15**: Stability Threshold (orange in maps)
  - **> 0.15**: Less healthy/Not Stable - Restoration (red in maps)
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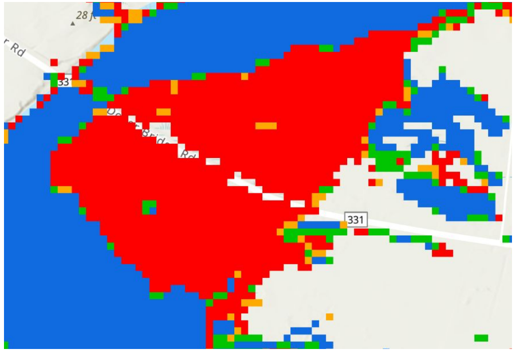
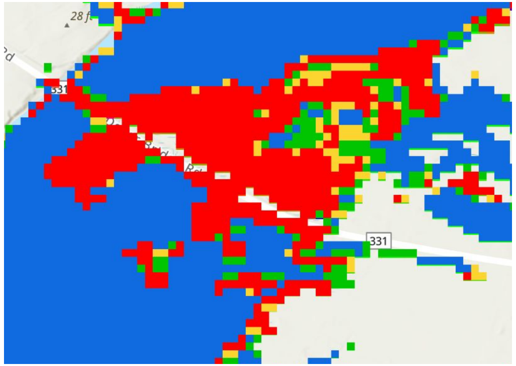
Dover Bridge Wetland

1985



2022



Aerial Imagery Supports Trends Shown by UVVR

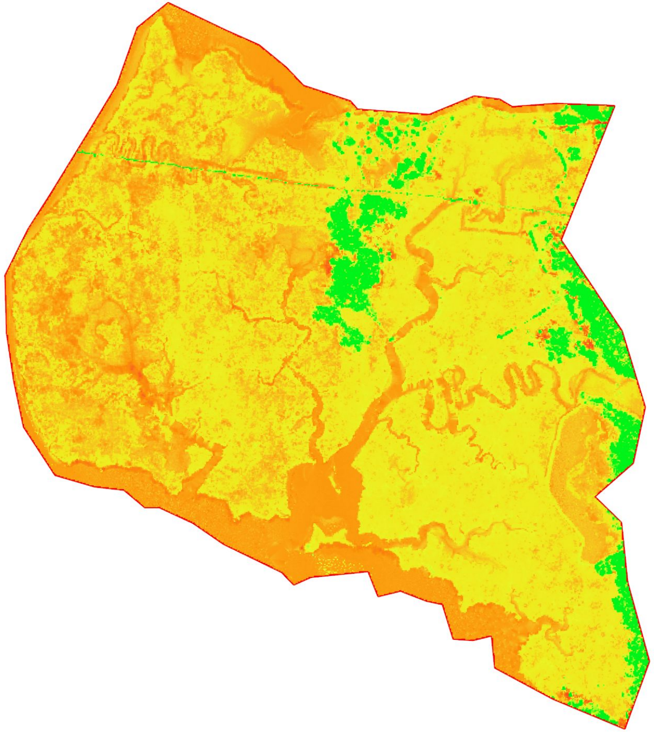
Dover Bridge Wetland

2005

2023

Elevation

- Loss of Elevation can signify a vulnerability to sea level rise and marsh loss
- There are bare Elevation Rasters from 2003 and 2013 available online
- Can take the difference of Digital Elevation Models (DEMS) (**ΔElevation = DEM_{2013} - DEM_{2003}**) to calculate the difference of elevation between the two years



ΔElevation 2003-2013 Choptank Wetlands Preserve Area

Creating a Vulnerability Index

- For each marsh, combine change in area, UVVR, and elevation to quantify a vulnerability index that can inform where to prioritize management

$$\text{Vulnerability} = \Delta A_M + \Delta U + \Delta E$$

Where:

ΔA_M = some factor relating to change in marsh area

ΔU = some factor relaying to change in UVVR

ΔE = some factor relating to change in elevation

Future Predictions of SLR and Marsh Changes

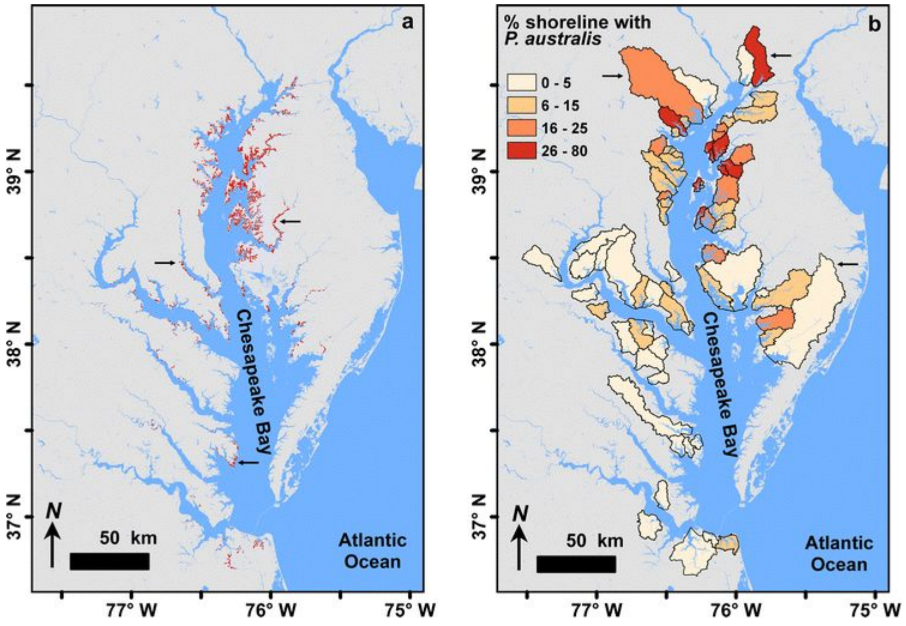
- By 2050: East shorelines are expected to see a 0.2m to 0.3m increase in sea level. North Chesapeake Bay typically runs higher than the average.
- Many Bay marshes can track moderate SLR via sediment accretion and plant growth, but **thresholds exist**—once SLR outpaces vertical gain, drowning/fragmentation accelerates.
- Elevation change from 1.8 ± 2.7 mm/yr to 5 mm/yr below what was needed to match global SLR at the time. Expect fragmentation and “marsh drowning” hotspots under higher SLR.

What is the current status of Ash tree populations, and what might future populations look like?

- Ash tree populations throughout the Choptank River wetlands are experiencing rapid dieback
- Primary Cause: Emerald Ash Borer
  - First detected in the region in 2015
  - Less known are impacts from saltwater intrusion.
- Species Affected:
  - All native ash species, especially Pumpkin Ash
- Future Outlook
  - Functional extinction is likely
- Management Options
  - Biological Controls
  - Proactive restoration planning
  - Adaptive management and monitoring

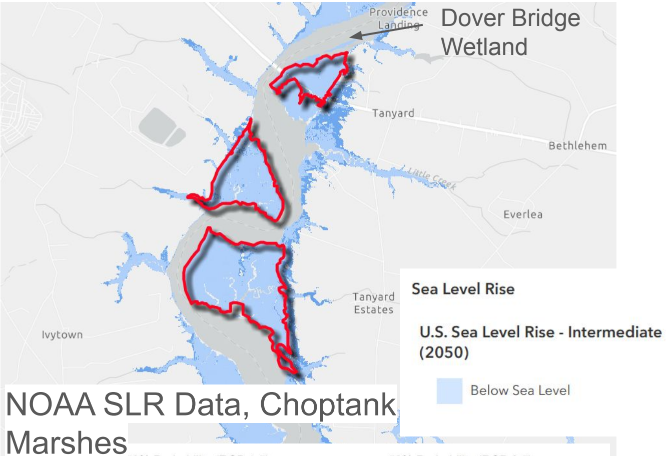
What is the current status of invasive *Phragmites australis* across the wetland, and how is it affecting ecosystem function?

- *Phragmites australis* continue to aggressively spread throughout the wetland
- Ecosystem Function Impacts:
  - Negative - Biodiversity Loss & Genetic Homogenization
  - Potential Positives - Sediment Accretion, Marsh Stability, and Organic Matter Accumulation

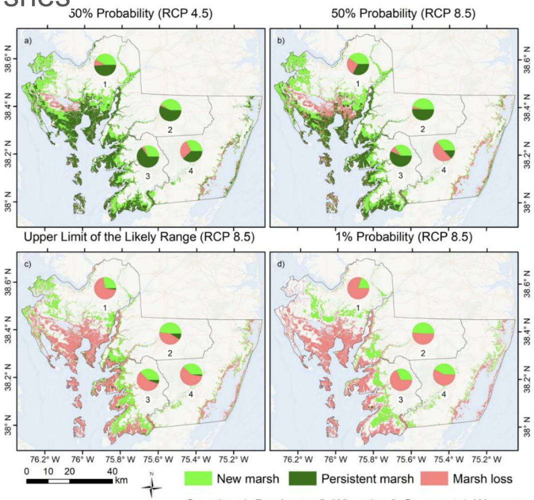


How will sea level rise affect the Choptank River tidal marshes?

- There is significant variability and unknowns in terms of local changes related to SLR and subsidence
- **What we do know**: Topographic variability has potentially larger effects on marsh persistence with SLR (i.e. chance of marsh migration) over anthropogenic barriers and causes like developed land uses and drainage
- Right diagram - displays what type of analyses we are planning to do for Choptank
- Saltmarsh area > Tidal freshwater area
    - Supported by professional interviews
    - SLR is a highly existential threat



NOAA SLR Data, Choptank Marshes

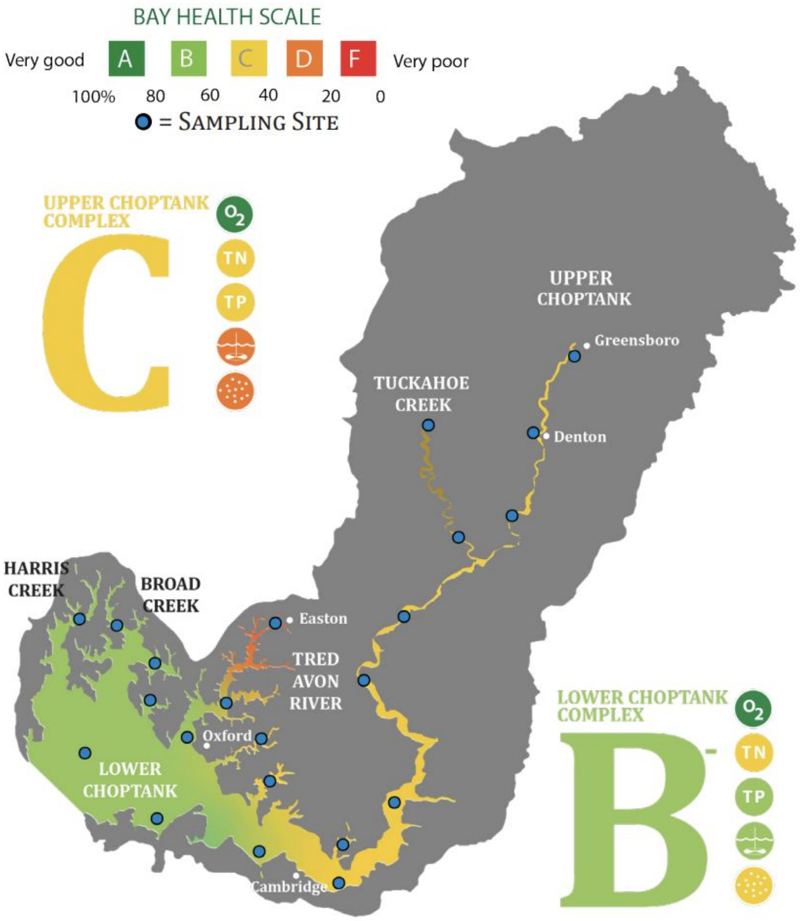


de Lima et al., 2024

How do anthropogenic activities and development affect the Choptank River and its surrounding wetlands?

- Farmers are a crucial stakeholder on the choptank river
    - Agriculture represents 32% of land area in Maryland
        - CT Watershed - 62% agricultural
            - 50% historically drained for crop production
- Difficulties with water quality and nutrient runoff
- Affect routes for Marsh migration

- Our marsh sites are in the Upper Choptank complex, where it received a Bay Heath Scale grade of C in 2024



What are the sociological conditions of the Choptank River, and who are the relevant stakeholders?

FARMERS

What are they experiencing

- Saltwater intrusion and loss of crop yield
- Marshland migrating into their properties
  - Marsh migration pathways

How are they managing?

- Limited potential for salt-tolerant crops
- Various government programs that *incentivize,* not require farmers to use marsh-friendly practices on their land
  - Conservation Easements (NRCS)
  - Conservation Reserve Enhancement Program (CREP)
    - Farmers still control practices
- "Voluntary practices rarely move the needle"

Objectives for Future Programming and Research	Votes for Most Important (%)	RAD Alignment
Developing cost-effective drainage options to reduce flooding	40%	R
Mapping current and forecasted saltwater intrusion areas	35%	R, D
Developing carbon credit/carbon sequestration programs and markets	30%	R, A, D
Developing new markets for alternative, salt-tolerant crops (e.g. switchgrass, salt hay)	25%	A
Developing more affordable erosion control options	25%	R

Sudol et al., 2023

Reiteration of Deliverables

1. <u>Coastal Wetland Resilience Plan for the Choptank River Ecosystem</u>
    a. Literature review
        i. Native and Invasive species presence
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    a. Historical changes
    b. Future projections

Some current questions

- Is there available data on sediment accretion rates and loss in the Choptank River?
- What other parameters might make sense to track over time to analyze marsh change over time?
- What strategies are best to most effectively collaborate with on the ground stakeholders like farmers?
- How do we prioritize and decide on restoration strategies (i.e. biocontrols, sediment replenishment, replanting, etc.) with such limited resources?

Citations

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